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INJECTION MOULDING MACHINE COMPRISING A LINEAR MOTOR

SPECIFICATION

The invention pertains to a closing device in the form of an injection molding machine for plastics with a stationary mold clamping plate and with a movable mold clamping plate, which can be operated by a linear motor.

A closing unit in which the end plate cooperates with the plunger to form a linear motor is known from DE 37 15 161 A1. The 3-phase windings are provided in the end plate and the plunger is designed as a "rotor" rail.

The disadvantage of this design is the relatively weak closing force which can be exerted by the linear motor. In another embodiment, therefore, an electromagnet is provided to produce the required closing pressure; when current is flowing through this electromagnet, it induces a force on the plunger directed toward the mold.

The efficiency of linear motors is especially poor at low speeds and when no motion at all is occurring. In the design described in the previously cited document, however, the maximum demand for force occurs as the closing force is being built up. The only movement which occurs in this phase is that which results from the expansion of the tie bars. This leads to an uneconomically large installation cost for the linear motor and for the converter required to operate the drive.

It must also be expected that the amount of energy consumed will be uneconomical in comparison with rotating motors. This disadvantage cannot be avoided by the use of a divided end plate provided with electromagnets to build up the closing force. The expansion of the tie bars leads in this solution to a considerable widening of the air gap and thus to a drastic drop in the amount of force which can be transmitted. The only way to compensate for this is to increase the size of the magnets of the tie bar to an uneconomical extent.

In the proposed solution, furthermore, the closing force must continue to be actively applied during the injection, holding pressure, and cooling phases, which means that large amounts of energy must be consumed continuously.

An injection-molding machine is known from EP 0 280 743 B1, in which a linear motion element, here a metering/injection screw, is designed as a linear motor. The linear motor has a cylindrical form, which corresponds to a movable element with a circular cross section.

This design is called a solenoid motor and is used for applications with low force requirements. Solenoid motors achieve only a fraction of the force which can be generated by linear motors of the single-comb or multi-comb type.

The forces required to move the screw of an injection molding machine in a linear manner cannot be compared with the closing forces required to close the mold of an injection-molding machine; that is, they are typically are 5-10 times smaller. Because no additional rotational movements of the axle, which is moved in a linear fashion, are required to close the mold, a solenoid motor offers only disadvantages for this application.

A plastic injection-molding machine is known from DE 38 18 599 A1, in which at least some of the working elements are driven by arrangements of electrically superconducting magnets, the conductors of which are cooled by a coolant to a temperature below the transition point. One of these working elements is a toggle lever for closing the mold, for which electrically superconducting linear electromotors are provided for the linear motion.

This device suffers from the disadvantage that, to achieve the transition temperature required for the superconducting state, a conductor winding is required which consists of a special alloy, which must also be cooled. An alloy of this type consists in particular of the expensive metal lanthanum or yttrium, plus barium, copper, and oxygen. The transition temperature is reached in particular by the use of liquid nitrogen and is thus associated with

significant technical effort.

The invention has the goal of creating a closing device of the general type in question which makes it possible by means of a simple design to move the movable mold clamping plate and to hold it in position at low expenditure of energy and without contamination.

The invention achieves this goal by means of the features of Claim 1.

According to the invention, at least one linear motor is connected to a force transmission element, which is connected in turn to a lever mechanism. This force transmission element can be designed as a crosshead or as an actuating frame.

Double-toggle levers are used here, where four-point and five-point toggle levers are preferred.

The geometry of the individual levers and the control program are selected so that, in the closed position of the movable mold clamping plate, the plate is held without any consumption of energy during the closed phase.

To achieve an especially short design, the linear motors are installed between the force transmission element and either the end plate or the movable mold clamping plate. In an especially advantageous design, the stationary part is attached to the end plate, and the mobile part is attached to the force transmission element. As a result, there is no need for a drag line.

In another advantageous design, a tie bar of the closing unit is used as the reaction rail of the linear motor.

During the closed phase of the movable mold clamping plate, the linear motors are turned off. As a result of this measure, the noise level is reduced and energy is also saved.

This is achieved by the use of toggle levers, which have such dimensions and are actuated in such a way via a control program that the dead center point is passed.

In another design, an arresting element is provided, which, during the closed phase, holds or grips at least one lever in a form-locking or friction-locking manner. The arresting

elements are designed so that drive energy is required only for the locking and unlocking processes.

According to the invention, linear motors are used in a pairwise arrangement. As a result of this design, the gap forces are essentially compensated.

An essential advantage of the invention is that the linear motion is produced directly, without the need to convert a rotation into a translation by the use in particular of a gear transmission. The elimination of a transmission minimizes the maintenance work required and increases the reliability of the machine. Without a transmission, the drive operates without any hysteresis or clearance at all, which increases the precision and the controllability of the motion.

The principle of the linear drive imposes no limit of any kind on the speed or on the force of the motion, as is associated with a solution in the form of a transmission or a worm.

An example of the invention is shown in the attached drawing:

Figure 1 shows a closing device with an actuating frame;

Figure 2 shows a closing device with a crosshead;

Figure 3 shows an arresting device designed as a brake;

Figure 4 shows an arresting device designed as a stop block; and

Figure 5 shows a free-space machine.

Figures 1 and 2 show an injection molding machine with a stationary mold clamping plate 11, a movable mold clamping plate 12, and an end plate 13. An injection cylinder 15 is mounted on the stationary mold clamping plate. The mold 16 is attached to the mold clamping plates 11, 12.

Figure 1 shows an injection-molding machine with a force transmission element, which is designed as an actuating frame 21.

The movable mold plate 12 can be seen in the open position in the upper part of the

figure. Between the movable mold clamping plate 12 and the actuating frame 21 is a five-point toggle lever 31-33.

The inductor combs 41, 43 of two linear motors are arranged in a pairwise manner as double-comb motors in the actuating frame. The reaction rails 42, 44 are connected to the end plate 13.

To supply energy and cooling water, the actuating frame 21 is connected by way of a drag line 45 to the end plate.

The movable mold clamping plate can be seen in the closed position in the lower part of the figure. Between the mold clamping plate 12 and the end plate 13 there is a four-point toggle lever 31-33.

An inductor comb 41 is provided in the actuating frame 21. This comb surrounds a tie bar 14, designed as a reaction rail 42.

Also in the lower part of the figure, we see that the tie bar 14 is guided by a second inductor comb 43, which is mounted in the movable mold clamping plate 12.

In Figure 2, the force transmission element is designed as a crosshead 22.

In the upper part of the figure, we see the movable mold clamping plate between the movable mold clamping plate 12. Under the end plate 13 is a four-point toggle lever 31-33. The levers 31 and 32 have passed the dead center point and can be kept in the closed position without the consumption of energy. The toggle levers 31, 32 are connected to the crosshead by the lever 33. A reaction rail 42 is attached to the crosshead; this rail is in working connection with an inductor comb 41. The inductor comb 41 is arranged parallel to another inductor comb 42, which is connected via a reaction rail 44 to the crosshead 22.

In the lower part, between the movable mold clamping plate 12, which is in the open position, with a five-point toggle lever, is connected to the crosshead 22.

Figure 3 is a sectional view of a lever 33, which can be held by a friction-locking

component 51. In the upper part of Figure 3, the component 51 is designed as a set of grippers, which can be held in the closed position by a spring 54. To open these grippers, a linear motor 53 is provided on the end of the grippers opposite the lever 33.

In the lower part of the figure, the friction-locking component is designed as a disk brake, which holds the lever 33 via springs 54 and which can be opened by a linear drive 53.

Figure 4 shows a form-locking component, here in the form of a wedge 55, which can be moved against the lever 33 by a linear motor 53.

Figure 5 shows a free-space machine with the stationary mold clamping plate 11, which is connected via lever 33 and lever 31, connected in articulated fashion to each other, to the movable mold clamping plate 12. The toggle lever, consisting of the levers 31 and 32, is connected to a linear motor consisting of the reaction rail 42 and the inductor comb 41.

Parts List

Injection-Molding Machine

11 stationary mold clamping plate
12 movable mold clamping plate
13 end plate
14 rollers
15 injection cylinder

Force Transmission

21 actuating frame
22 crosshead (force transmission element)

Levers

31 lever connected to 11
32 lever connected to 13
33 lever connected to 21, 22
31, 32 (toggle levers)

Drive

41 first inductor comb
42 first reaction rail (linear motor)
43 second inductor comb
44 second reaction rail
45 drag line

Arresting

51 friction-locking component (brake)
52 form-locking component (stop block)
51, 52 arresting device
53 drive for 51, 52